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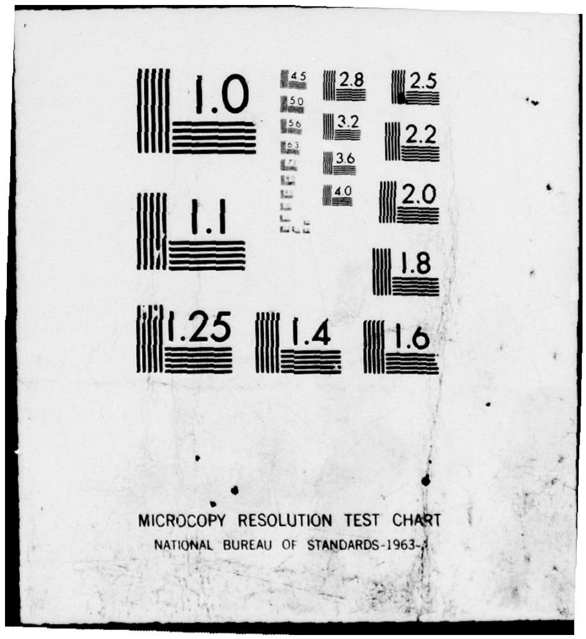
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NAVAL OCEANOGRAPHIC OFFICE TRANSLATION NOO T-33 (275)

NEKOTORYYE OSOBENNOSTI GIDROLOGII DATSKOGO PROLIVA

(Some Hydrologic Features of Denmark Strait)

Data from the summer 1958 cruise of the ES SEVASTOPOL'

Pages 74-92 in Trudy VNIRO, n. XLVI, n. 1, 1962.

1978

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Data from the SEVASTOPOL' cruise (summer 1958) are compared with ANTON DOHRN and SCOTIA data for the same season in Denmark Strait. Three main water masses are defined; (Arctic, Atlantic and mixtures of the two) from T-S (temperature - salinity) profiles and cross-sections. Irminger and East Greenland currents are discussed.

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Some Hydrologic Features of Denmark Strait

(Data from the summer, 1958 cruise of the ES' SEVASTOPOL')

Features of the Water Masses

Based on literature sources (4, 6) and data on temperature and salinity that we obtained in Denmark Strait (mainly on the Greenland-Iceland Sill and off the southeast coast of Greenland), it can be said that the contours of the main water masses of Atlantic and Arctic origin are clearly defined. As a result of interaction between these different water masses, an important property of Denmark Strait is apparent - the presence of the Arctic Front. The front is represented by a rather narrow belt (the zone of maximum horizontal temperature and salinity gradients).

It is here, in the area of the Arctic Front, that water with intermediate hydrologic characteristics (i.e. temperature and salinity) is formed through the intense mixing of various water masses. For this reason, it is possible and necessary to identify this particular intermediate water mass. In addition, new types of mixed water were found in the area that we investigated, water from continental runoff and Atlantic water, which were observed off the coast of Iceland.

Various water masses and their variations resulting from mixing and the action of a number of local and seasonal factors can be traced in great detail by analyzing T-S (Temperature-Salinity) curves prepared from data obtained by the SEVASTOPOL' expedition in the summer of 1958. Let us discuss, first, the Atlantic water mass, which is widely represented in Denmark Strait and the Irminger Sea.

A rather detailed description of the water mass was obtained at stations occupied in the area of the Irminger Current southwest of Cape Reykjanes, i.e. where Atlantic water enters Denmark Strait (fig. 1). This water mass is almost uniform, if one consideres its physical and chemical properties. Only at a depth of 700 m does the salinity decrease somewhat, yet it remains above 35.1°/₀₀. The water temperature is about 6 to 8°C, except in the surface layer, which is heated by solar radiation.

Moving toward the Greenland-Iceland Sill and southward along the continental slope of Greenland, Atlantic water is changed substantially through mixing with other water masses and the effects of seasonal, zonal and other factors.

In the southern part of the Greenland-Iceland Sill, T-S curves preserve a form typical of Atlantic water (fig. 2), which attests to

the similarity of processes that create the existing temperature and salinity distribution. The physical and chemical properties of the water mass are somewhat changed, but the salinity is rather high (more than 35°/oo), while the temperature varies from 5.5 to 7.5°C. In some instances a temperature drop and even a decrease of salinity with depth is seen, which indicates that the (Atlantic) water has mixed with the local bottom water of the Greenland-Iceland Sill that evidently is formed through vertical convection in winter (fig. 2-d).

Sometimes, evidently due to wind action, cold surface water of Arctic origin penetrates the area usually occupied by Atlantic water, sometimes bringing drift ice. The shape of the T-S curves of the surface water layer is somewhat changed (fig. 2b) with the appearance of such foreign water (which results from the occurrence of specific hydrometeorologic conditions, because of the small area of Denmark Strait and clear definition of the Arctic front).

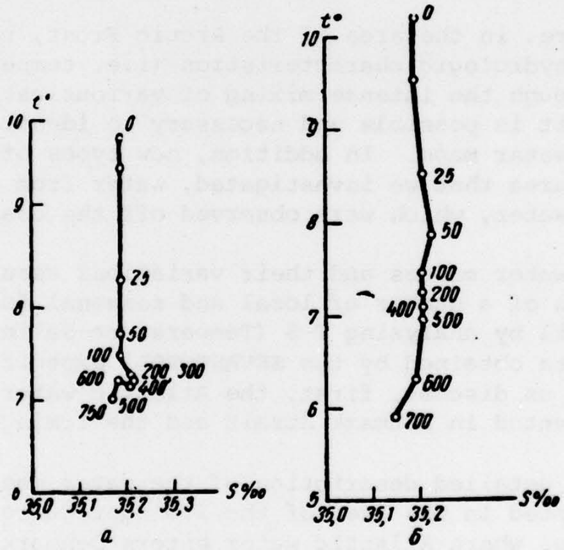


Figure 1. T-S curves: a - at St. 1578; b - at St. 1579.

In addition, we also plotted T-S curves to define the Atlantic water that adjoins the East Greenland current flowing along the coastline south of latitude 64°N (fig. 3). In all instances the thin surface layer (in various forms) is relatively diluted compared to the bottom layer, where the salinity is about 35°/oo or more. The salinity maximum is at depths of 50 to 200 m. The variation of T-S curves of the surface layer is associated here (as in the preceding

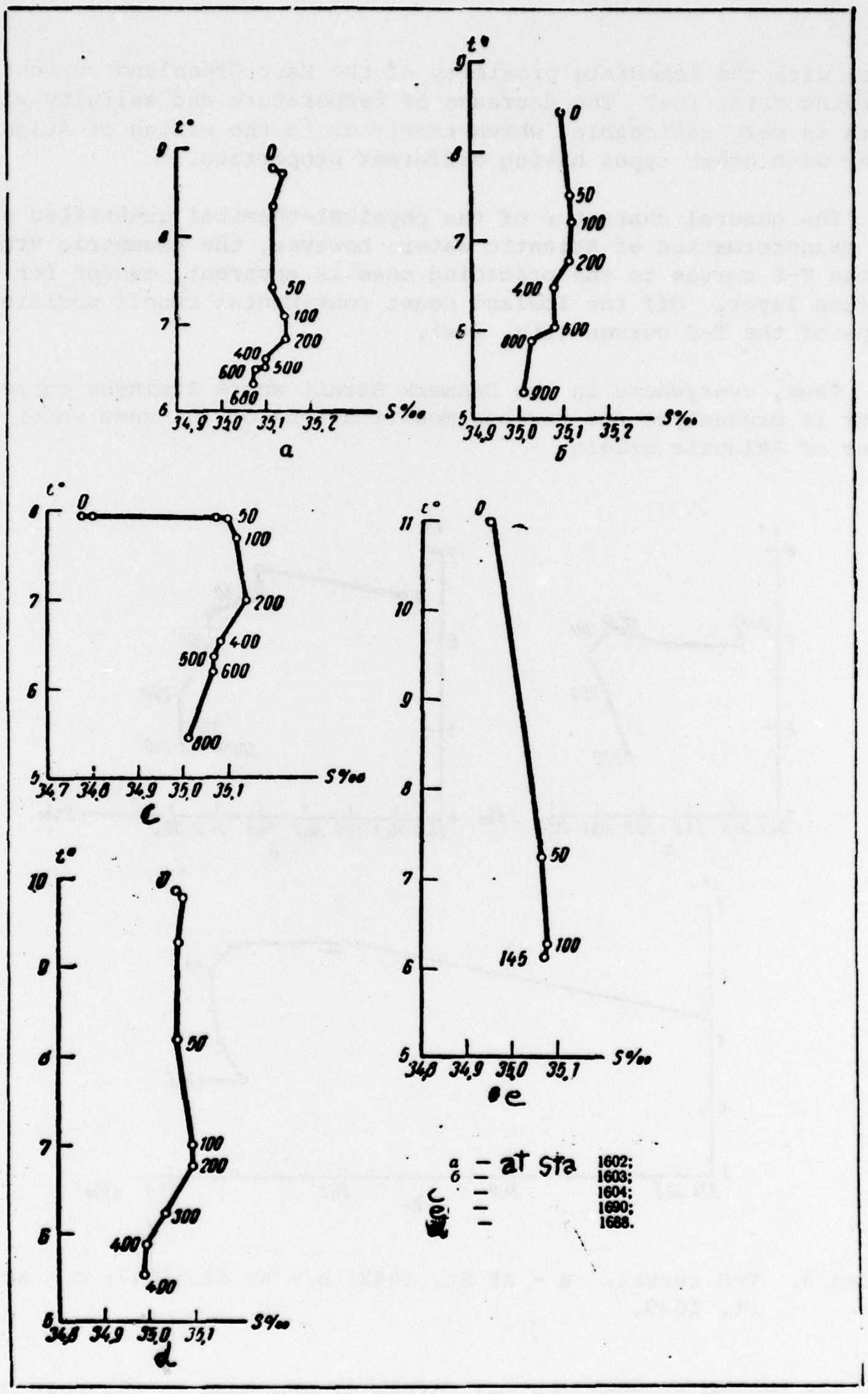


Figure 2. T-S curves.

case) with the immediate proximity of the East Greenland current carrying drift ice. The decrease of temperature and salinity with depth is very noticeable, which testifies to the mixing of Atlantic water with other types having different properties.

The general character of the physical-chemical quantities shows the transformation of Atlantic water; however, the geometric similarity of the T-S curves to the preceding ones is apparent, except for the surface layer. Off the Iceland coast continental runoff modifies the shape of the T-S curves (fig. 2-e).

Thus, everywhere in the Denmark Strait where Irminger current water is present, we see various modifications of the same water mass - water of Atlantic origin.

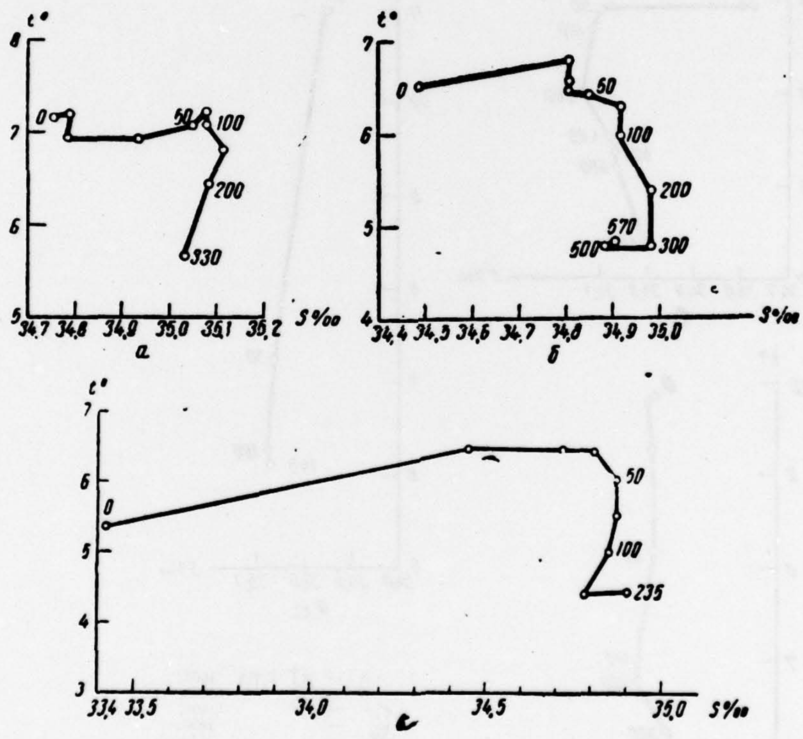


Figure 3. T-S curves. a - at St. 1642; b - at St. 1647; c - at St. 1649.

Let us now discuss the T-S curves of stations in the East Greenland current (fig. 4). The T-S curves that characterize these waters differ

considerably from the T-S curves of Irminger current water. This is understandable, because the origin of the water is different. In addition, the discussion of the T-S curves shows that, in the given case, we have to deal either with several variations of one water mass or with combinations of several different water masses.

First of all, this East Greenland current water, i.e. water of Arctic origin, which often carries drift ice, has physical and chemical characteristics that are entirely different from those of Atlantic water. Arctic water is especially clearly defined by the T-S curves of St. 1607 in the immediate vicinity of the Arctic Front. Here, in the upper 50m layer, we see negative temperatures, the salinity ranging from 32 to 33.8 ‰.

A comparison of the T-S curves of stations in various areas shows the unity of processes that are responsible for the typical features of surface water that is cold and of low salinity. At the same time, such a comparison shows a certain variability associated with the influence of local seasonal factors and interaction with waters of different origin.

Artic Surface Water with temperatures above 0° C was observed in many instances, which can be related to the location of our stations outside the core of the main branch of the East Greenland Current in an area fairly free of ice. However, the salinity was low as usual. In a number of cases, complex superstratifications of the surface water layer have been observed (fig. 4 b,c) that are of course, associated with irregular relief and intense turbulence (here we have to account for the proximity of Atlantic Water).

The T-S curves exhibit one more characteristic; varying thicknesses of cold surface water. This phenomenon can be explained by a more detailed analysis of T-S curves from various stations in the East Greenland Current. All these curves are characterized by a bend caused by presence of the warm intermediate layer of Atlantic water at a depth of 75 to 400m which is, of course, a branch of the Atlantic Countercurrent and runs beneath the East Greenland Current throughout its course. Thus, by analyzing the T-S curves, we find another water mass - water of Atlantic origin. Its mass determines the thickness of the cold surface layer. Interaction between these diverse water types leads to a complex pattern of superstratified water.

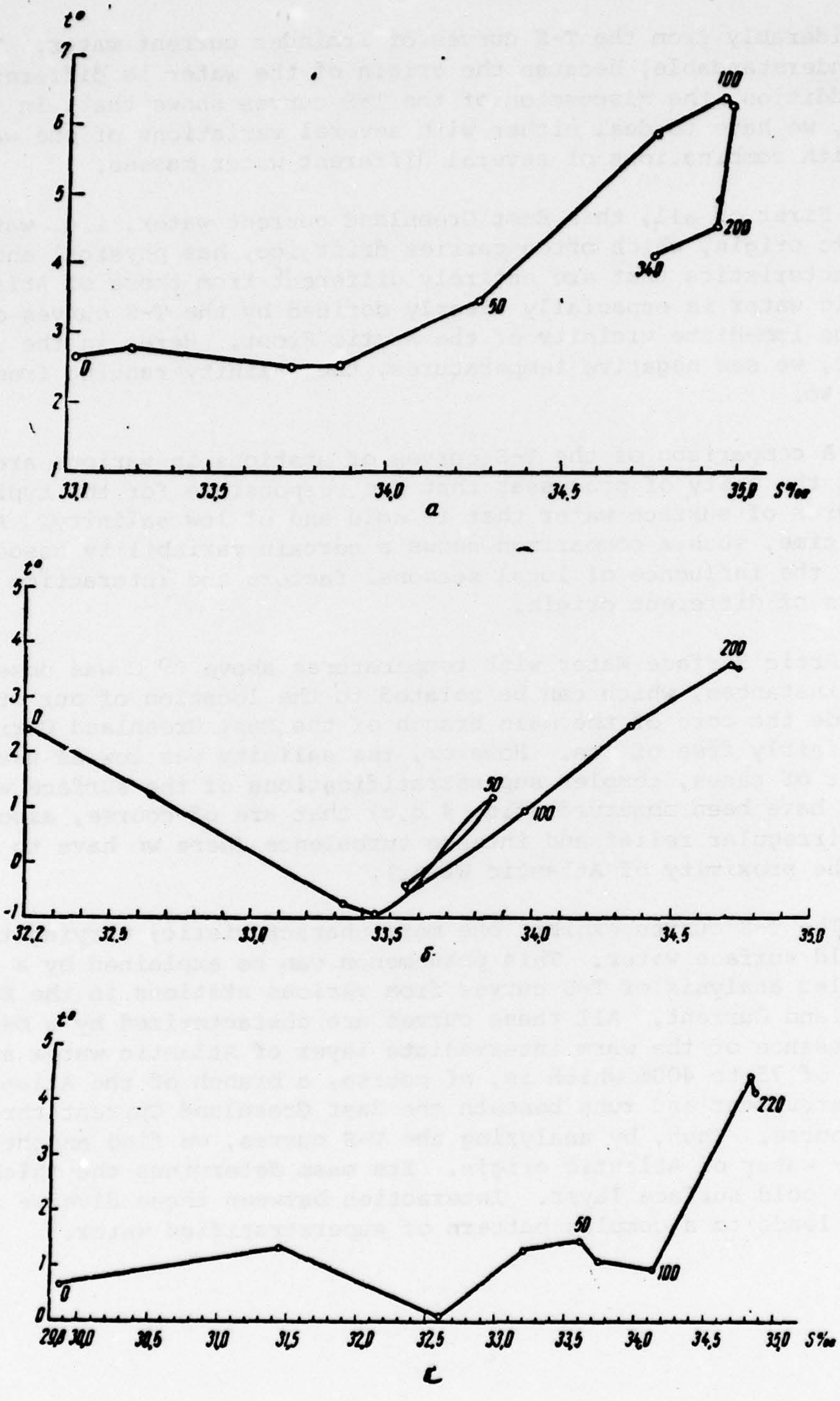


Figure 4: T- S curves: a - at St. 1636, c - at St. 1637.

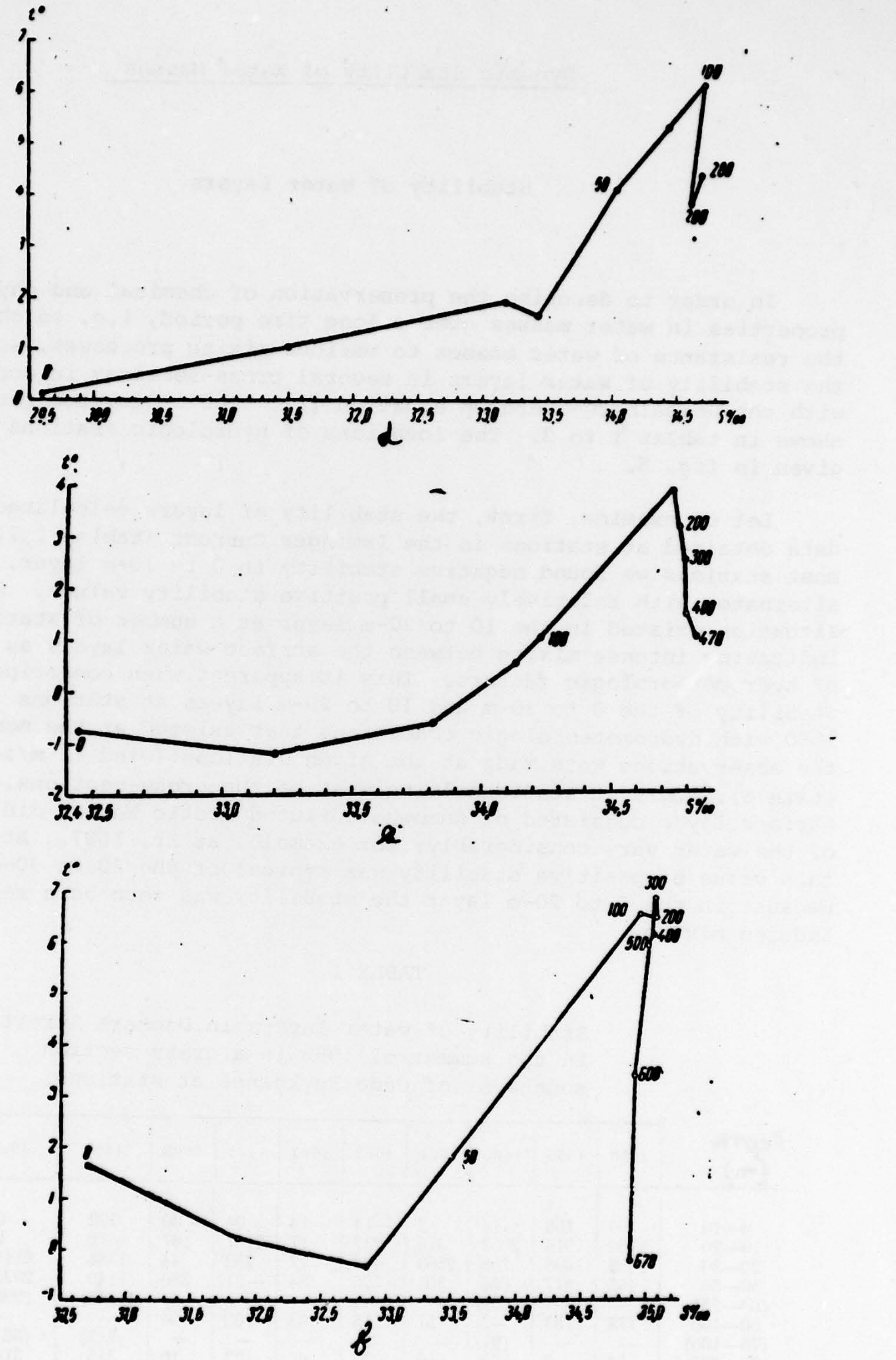


Figure 4 (cont-d): T-s curves: d - at St. 1650, e - at St. 1607; f - at St. 1637.

Stability of Water Layers

In order to describe the preservation of chemical and physical properties in water masses over a long time period, i.e. to characterize the resistance of water masses to various mixing processes, we calculated the stability of water layers in several cross-sections in accordance with the Hesselberg-Sverdrup equation [1]. The calculated results are shown in tables 1 to 3. The locations of hydrologic stations are given in fig. 5.

Let us examine, first, the stability of layers calculated from data obtained at stations in the Irminger Current (tables 1,2). At most stations we found negative stability in 0 to 10-m layer, which alternates with relatively small positive stability values. A similar situation existed in the 10 to 20-m layer at a number of stations, indicating intense mixing between the surface water layers as a result of hydrometeorologic factors. This is apparent when comparing the stability of the 0 to 10-m and 10 to 20-m layers at stations 1689 and 1690 with hydrometeorologic conditions that existed at the moment when the observations were made at the given stations (wind 12 m/sec, sea state 6). Only at stations lying west of the cross-sections, where the surface layer consisted of somewhat diluted Arctic Water, did the stability of the water vary considerably; for example, at St. 1687. At St. 1607 this value of positive stability was typical of the 20 to 30-m layer, because in the 0 to 20-m layer the stability was zero as a result of wind-induced mixing.

TABLE 1

Stability of water layers in Denmark Strait in the summer of 1958 in a cross-section southwest of Cape Reykjanes at stations.

Depth (m)	1598	1599	1600	1601	1602	1603	1604	1605	1606	1607
0—10	69	156	118	—2	—14	—14	94	—30	322	0
10—20	1750	1914	2953	316	237	17	2197	187	—16	0
20—30	1669	1698	708	2563	440	17	252	44	1388	6141
30—50	485	817	658	301	720	754	—21	380	1140	2828
(50—75)	—	—	(169)	—	—	—	—	—	(1488)	(998)
50—100	178	183	—	51	115	93	100	94	—	—
(75—100)	—	—	(91)	—	—	—	—	—	(215)	(321)
100—200	14	2	52	66	37	60	123	10	315	315
200—300	—	—	—	—	—2	10	8	16	70	24
300—400	—	—	—	—	—	—	—	79	185	0
400—500	—	—	—	—	17	29	16	—	—	48
500—600	—	—	—	—	—16	—	27	—	—	—
600—800	—	—	—	—	22	—3	25	—	—	—
800—900	—	—	—	—	—	67	—	—	—	—

At stations 1598 to 1600 a considerable positive stability was observed in the surface layers, because here (near the coast of Iceland) the effect of continental runoff is manifest: the saline water lies beneath the dilute warmer water.

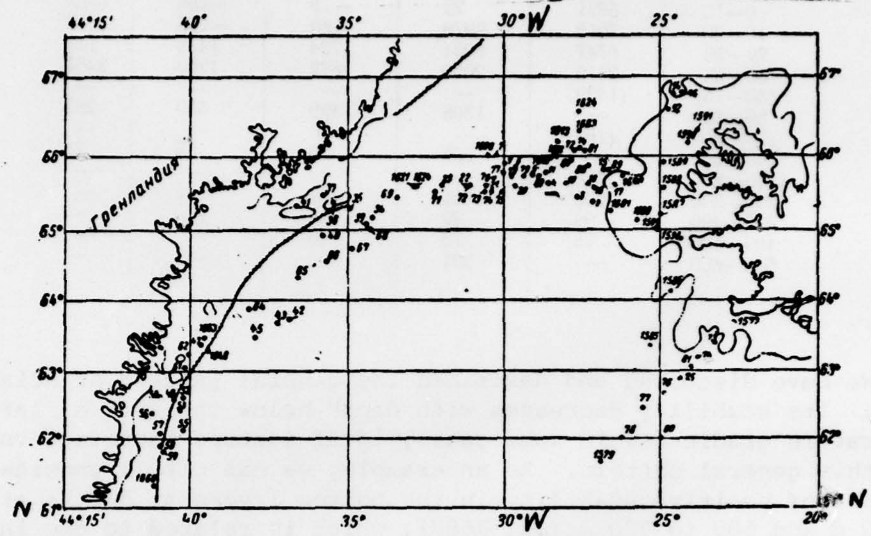


Fig. 5. Chart of hydrologic stations occupied during the SEVASTOPOL' cruise.

The distribution of stability in layers from 20 to 200m differs from that of the 0 to 10-m layers. Here, almost the entire area is occupied by water masses having a positive stability, which is especially pronounced in the 20 to 30-m and 30 to 50-m layers. This is explained by the large temperature gradients (transition from the active layer, which is subject to the wind-induced mixing, to the main mass of Atlantic Water).

Deeper, the absolute values of stability decrease, in some cases small positive values alternate with small negative values. It is possible that the uniform water has been mixed as a result of dynamic processes.

TABLE 2

Stability of water layers in Denmark Strait in summer of 1958 at stations 1686....

Depth (m)	1686	1687	1688	1689	1690
0—10	5671	25	—15	—155	—55
10—20	7912	9979	180	—155	2
20—30	6747	8051	724	1434	133
30—50	2310	2056	872	1200	3463
(50—75)	(1439)	—	—	—	—
50—100	—	1308	399	359	283
(75—100)	(164)	—	—	—	—
100—200	—	100	30	55	23
(150—200)	(278)	—	—	—	—
200—300	208	—61	27	1	—
300—400	99	77	16	—	—
400—500	15	13	46	—	—
500—600	—	221	—	—	—

We have discussed and described the general pattern of Atlantic Water. Its stability decreases with depth below the zone of large temperature gradients. In some cases, local factors introduce variations into this general pattern. As an example, we can cite a considerable increase of positive stability in the bottom layers at depths of 500 to 600 m and 600 to 700 m (St. 1687), which is related to the influx of bottom water into the depression occupied by Atlantic Water. This bottom water was formed during the winter on the Greenland-Iceland Sill and is colder and more saline than Atlantic Water. As a result of mixing the water becomes denser and forms a distinctive anomaly.

Let us discuss data describing the stability of layers in the area occupied by the East Greenland Current (table 3). The water masses of this portion of Denmark Strait are rather stable, especially in the 0 to 50-m layer.

TABLE 3

Stability of layers in Denmark Strait in summer 1958 off the southeast coast of Greenland at stations 1634 to 1637.

Depth (m)	1634	1635	1636	1637
0—10	1199	8489	4334	12230
10—20	3793	4621	6462	10097
20—30	1109	1262	963	4186
30—50	1175	1126	1183	1471
50—75	437	928	667	573
75—100	340	471	1081	1172
100—150	38	103	368	479
150—200	397	—	328	91
200—300	−64	239	21	—

This is understandable because Arctic Water is found in the upper layer, beneath which lies an intermediate layer of Atlantic Water. Such a water structure is characterized by its great resistance to mixing. Differences in the physical and chemical properties of water in the area occupied by the East Greenland Current and Atlantic Water, which are defined by their different origins, is also seen in their differing stabilities. The East Greenland Current water has a more pronounced vertical stability than Atlantic Water of the Irminger Current.

CURRENTS

The scope of the hydrologic data gathered by the SEVASTOPOL' expedition in the summer of 1958 (like analagous data collected in the summer of 1957) is too small to plot a dynamic current chart. Nevertheless, the data provides current speeds in the cross-sections intersecting the branches of the Irminger and East Greenland Currents, because the presence of anomalies in physical and chemical characteristics or variations in the Arctic Front are directly related to fluctuations in the masses of these principal currents of Denmark Strait.

The planes of our cross-sections were normal to the main currents. Using the dynamic method (2), we calculated the current speeds between each pair of hydrologic stations. The reference level in our calculations was the sea bottom. Let us examine the cross-section located southwest of Cape Reykjanes (table 4), on which we can trace the alternation of current directions. Thus, in the sector between St. 1574 and 1575, 1575 and 1576 the current flows north and its speed is 4.6 and 6 cm/s on the surface; between St. 1576 to 1578 the current flows south at 615 cm/s, but between St. 1578 and 1579, the current flows north again with speeds up to 2.7 cm/s. Such alternation in current direction in a cross-section does not prove that the currents are flowing in different directions. Such a faulty concept may arise from the fact that, in our case, the currents are examined only in a plane normal to the cross-section.

Table 4

Current speed in cm/s in Denmark Strait in summer 1958 in a cross-section southwest of Cape Reykjanes at stations 1572 to 1578.

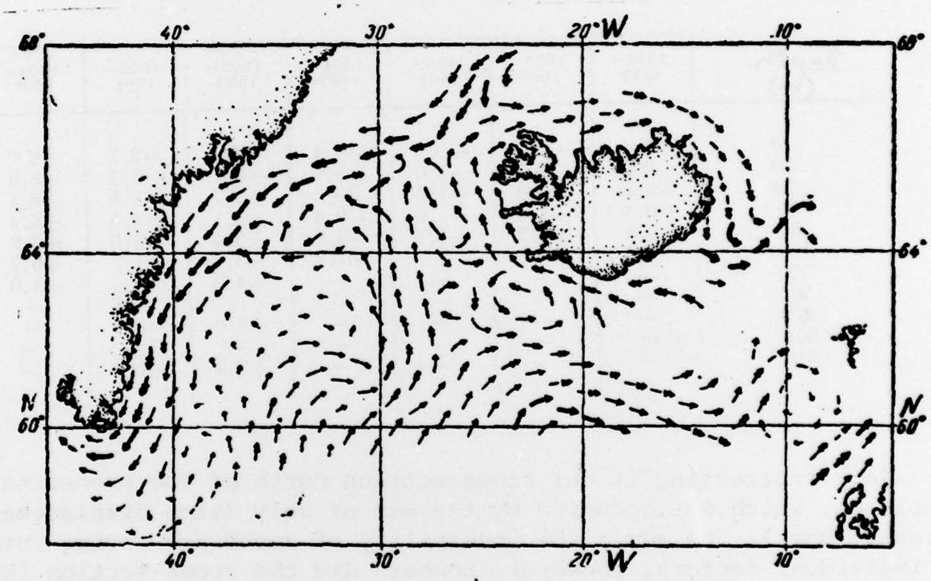
Depth (m)	1572–1573	1573–1574	1574–1575	1575–1576	1576–1577	1577–1578	1578–1579
0	+0,38	+0,19	+4,56	+6,2	–6,46	–0,65	+2,55
10	–0,19	+0,19	+4,56	+6,2	–6,46	–0,78	+2,70
25	–0,57	0	+4,56	+5,8	–6,08	–1,04	+2,70
50	–0,76	–0,19	+4,56	+5,2	–5,89	–1,30	+2,70
100	–0,38	–0,76	+4,37	+4,4	–5,70	–1,30	+2,55
200	—	–0,57	+3,42	+3,4	–5,13	–1,30	+2,40
300	—	—	+3,04	+3,4	–4,75	–1,56	+2,40
400	—	—	—	+2,2	–3,23	–1,82	+2,25
500	—	—	—	+0,6	–1,71	–1,82	+1,95
600	—	—	—	—	—	–1,43	+1,65

Note: Here and in subsequent tables, plus signs denote a current moving northward and minus signs denote a current moving southward.

This concept can be disproved by comparing current charts for the entire region. We obtained such a chart from calculations of data from the German expedition on the ship ANTON DOHRN (fig. 6). The chart was based on calculations of dynamic depth anomalies by plotting the corresponding dynamic horizontals. In examining the chart, we may notice a number of gyres and eddies.

Regrettably, we have scant material to compare with our calculated data that describe the speed of individual branches of the Irminger Current in summer between the end of June and July (the same situation exists in the East Greenland Current).

Fig. 6 Surface currents in Denmark Strait and in the Irminger Sea in June 1955 (according to ANTON DOHRN data).



V. A. Lednev [4], records a speed of 18 miles per day (38 cm/s). The data were based on observations of drifting fishing vessels southwest of Cape Reykjanes. However, it is difficult to state how dependable this figure is, because we do not know when and under what hydrometeorologic conditions the observations were made (they may include the effects of tidal currents, which are rather clearly evident in the coastal belt of Iceland.

At the same time, a comparison between our data from the summer of 1958 and the German ANTON DOHRN values for the same season in 1955 show a complete analogy of absolute speeds (see table 4). Also the cross-section that intersects branches of the Irminger Current in

Denmark Strait (table 5) confirms the presence of a number of eddies between individual branches of the Irminger Current (alternation of current directions in the cross-section). The current chart based on data from the ANTON DOHRN expedition shows such eddies clearly.

According to our data, speeds of the currents flowing northward range from 2 to 3 cm/s. Only seaward, between St. 1604 and 1605, do the speeds reach 6 to 11 cm/s. The speeds of currents moving southward fluctuate from 1 to 10-15 cm/s in various areas. The same speeds (except for magnitudes exceeding 10 cm/s) were measured by the German expedition.

Table 5

Current speeds in cm/s in Denmark Strait in summer 1958 at stations 1598 to 1605.

Depth (m)	1598–1599	1599–1600	1600–1601	1601–1602	1602–1603	1603–1604	1604–1605
0	+0,4	+2,5	–0,8	–9,4	+3,1	–2,7	+9,7
10	+0,6	+2,2	–1,0	–9,6	+2,7	–2,3	+8,9
20	+0,8	+1,8	–1,0	–9,6	+2,7	–2,3	+8,4
30	+0,8	+1,5	–1,0	–9,4	+3,1	–2,5	+8,4
50	+0,8	+1,2	–1,1	–8,6	+3,4	–2,5	+7,8
100	+0,4	+0,5	–0,8	–7,7	+3,7	–1,7	+6,2
200	—	—	—	—	+4,0	–1,0	+4,9
300	—	—	—	—	—	—	—
400	—	—	—	—	+4,0	–0,6	—
500	—	—	—	—	—	—	—
600	—	—	—	—	+2,2	+0,4	—

Very interesting is our cross-section north of the preceding one (table 6), which was occupied by the end of July (time displacement being 25 days). We admit the possibility of southward moving currents in individual sectors. However, nowhere did the cross-section intersect areas where the current moved northward, although on earlier dates we observed a well-defined Atlantic water mass north of the location. This water had obviously been brought by the Irminger Current (for example, St. 1591-1592).

Table 6

Current speeds in cm/s in Denmark Strait in summer 1958 at stations 1687 to 1690.

Depth (m)	1687–1688	1688–1689	1689–1690
0	–27,0	+0,54	–0,58
10	–20,5	+0,27	–1,16
20	–15,7	0	–1,74
30	–12,7	–0,27	–2,61
50	–9,4	–0,27	–3,48
100	–5,9	0	–2,32
200	–5,4	–0,27	—
300	–4,9	—	—
400	–4,3	—	—

Two possibilities come to mind: the current is either forced to flow in a narrow belt along the coast of Iceland (our cross-section did not reach the coast, the distance being 40 miles), or the weak Irminger (its northern branch) Current can not cross the Greenland-Iceland Sill, because of strong winds during the time of observation, and is forced to move counter clockwise under the impact of Arctic Water and join the flow of Arctic Water moving southwestward.

Let us return to the problem of eddies. We must determine whether the eddies are constant or temporary, caused by seasonal changes in the current regime. This problem can be resolved only by regular seasonal and annual observations. The data at our disposal pertain to the summer of 1955, 1957 and 1958. If the observations conducted in 1955 and 1958 indicate the presence of a number of such eddies, the properties of the Irminger Current that were observed in the summer of 1957 (the cross-section of 1957 was repeated with small changes in 1958) make us question its permanent existence.

Almost the entire cross-section (table 7) showed currents moving northward, the current flowed southward in only one sector, between St. 1161 and 1162, however, its speed was insignificant, reaching 1.0 cm/s.

Table 7

Current speeds in cm/s in Denmark Strait in summer 1957 at stations 1157 to 1165.

Depth (m)	1157–1158	1158–1159	1159–1160	1160–1161	1161–1162	1162–1163	1163–1164	1164–1165
0	+2,6	+6,0	+1,1	+1,7	−1,9	+16,5	+26,7	+6,5
10	+2,6	+5,5	+0,9	+2,4	−1,6	+16,5	+26,2	+6,5
20	+2,8	+4,9	+0,7	+1,9	−1,9	+16,7	+25,6	+6,5
30	+3,0	+4,2	+0,7	+1,4	−1,9	+16,9	+25,1	+6,5
50	+2,8	+3,1	+0,5	+0,5	−1,6	+17,3	+24,3	+6,7
100	+0,8	+1,0	+0,2	+0,5	−0,6	+17,3	+23,0	+7,7
200	—	—	—	—	+1,9	+16,0	+22,1	+17,3
300	—	—	—	—	+4,3	+14,8	+22,7	+21,6
400	—	—	—	—	—	—	—	—
500	—	—	—	—	—	+10,6	+21,6	—

Note: St. 1157 is located at 64° 56' N and 24° 25' W;
St. 1165 is at 65° 52' N and 29° 39' W.

At the same time, the speeds of currents moving southward in the 1958 cross-section fluctuated in various areas from 1.0 and 2.7 cm/s to 9.6 cm/s.

It appears from this comparison that in the summer of 1957, in contrast to 1958, insignificant eddies were noted in limited sectors of the Irminger Current in Denmark Strait. In addition, according to data obtained in the summer of 1957, the speeds of currents flowing northward were considerably greater than in 1958. If in 1958 the minimum speeds of currents varied from 0.4 to 2.5 and 3.1 cm/s at the surface (in various sectors), in 1957 they varied from 2.6 to 6.0 cm/s. The minimum speeds at the surface were 9.7 cm/s in 1958, and 16.5 to 26.7 cm/s in 1957. The data show that the mass of Atlantic Water in the summer of 1958 (and also in 1955) was one-half to one-third the size it was in the summer of 1957.

It is evident that the presence of eddies in the Irminger Current region, as well as in the area of its propagation, can be associated with fluctuations of the water mass involved in the entire current system. The complex bottom relief of Denmark Strait undoubtedly contributes to the creation of these phenomenon. The existence of eddies is additionally supported by the table of current speeds (table 8) calculated for a more northern cross-section that intersects Denmark Strait (the cross-section was occupied by the SEVASTOPOL' expedition during August 4 to 6, 1957) and lies within the boundaries of the Greenland-Iceland Sill where Denmark Strait transits into the Greenland Sea.

The data in table 8 show eddies in this northernmost area, where Arctic Water is quite influential and where Atlantic Water does not penetrate. It is possible that the eddies are more stable here than farther south, but regrettably, we do not have data on which to base more more detailed conclusions. The development of such water circulation is, in large measure, caused by the complex relief of the Greenland-Iceland Rise.

Table 8

Current speeds in cm/s in 1957 at stations at the junction of Denmark Strait with the Greenland Sea.

Depth (m)	1192—1190	1190—1188	1188—1184	1184—1199	1199—1200	1200—1201
0	+5,32	—34,50	—14,64	+0,84	+0,32	—1,40
10	+5,32	—31,20	—12,48	+0,84	+0,64	—2,80
20	+5,70	—28,80	—11,04	+0,84	0	—2,24
30	+5,70	—26,70	—9,36	+0,72	—	—
50	+5,70	—22,50	—7,68	+0,72	—3,20	0
100	+4,94	—15,00	—6,48	+0,72	—2,24	—0,84
200	+2,66	—10,80	—4,56	+0,36	+0,64	—1,40
300	—	— 8,70	—	—	—	—

Depth (m)	1201—1202	1202—1203	1203—1204	1204—1205	1205—1206
0	+16,24	—10,15	+4,40	+2,38	+7,41
10	+16,52	—13,65	+8,00	—	—
20	+15,12	—14,70	+10,00	+2,21	+4,29
30	—	—12,25	+10,00	+2,38	—
50	+8,96	—8,40	+10,00	+2,72	—1,95
100	+4,48	—4,20	+10,40	+2,21	—
200	+1,68	—1,75	+9,00	—	—
300	—	—1,05	—	—	—

Note: Location of St. 1192: 67^{o} 42' N and 32^{o} 08' W;
Location of St. 1206: 65^{o} 47' N and 24^{o} 21' W.

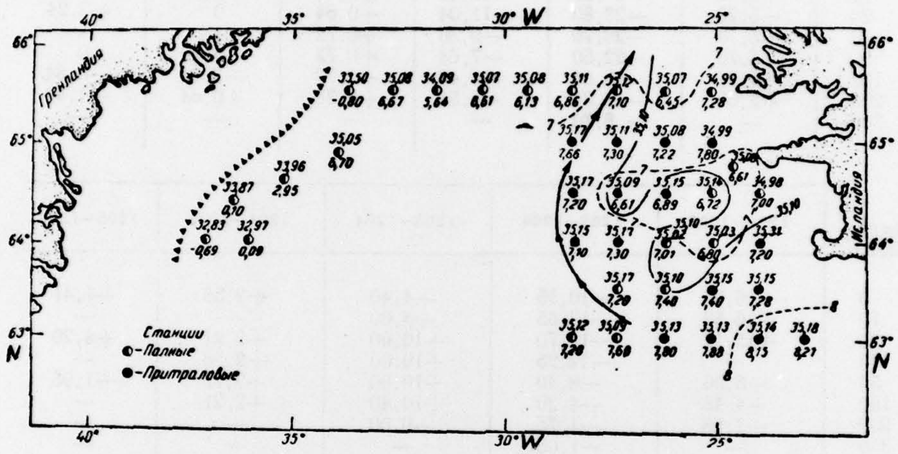
We have no data to show seasonal fluctuations in eddy activity. However, such fluctuations must exist because the water mass involved in the movement fluctuates seasonally.

One more aspect is of interest, the speed distribution of the Irminger Current seen in the tables. The main flow of warm Atlantic Water in Denmark Strait (the largest and most clearly defined) occurs in the seaward sectors of cross-sections between longitudes 27.5^{o} and 29^{o} W. This water undoubtedly is involved in a "disrupted" (south) circulation within Denmark Strait. The Greenland-Iceland Sill is evidently the greatest contributor to this situation. The sill deflects the water westward, where it can be reinforced by cold Arctic Water of the East Greenland Current, so that the water moves south and southwest (see fig. 6).

The seaward position of the main branch of the Irminger Current is

shown by the surface temperature and salinity in spring before the period of intense heating, when surface properties may reveal the currents. The chart showing the distribution of surface temperature and salinity for May 1954 has been taken from data collected by the expeditionary ship SCOTIA (fig. 7). They show that the highest water temperature and salinity occur in the western part of this peculiar "screen" of hydrologic stations. Therefore the authors of the chart consider that the water flow marked by arrows is the main current passing through Denmark Strait (7).

Figure 7. Chart of the distribution of surface water temperature and salinity for May 1954 (from SCOTIA data). The upper numbers denote salinity in $^{o}/oo$, the lower numbers show temperature in ^{o}C.



According to the SCOTIA data the maximum speed of the north-flowing current is 4.6 miles per day, i.e. 9.3 cm/s, in the northern cross-section (at approximately 65° 30' N). This value conveniently coincides with the maximum speed that we found in the farthest seaward part of the cross-section in the summer of 1958 (see table 5).

By comparing the velocity characteristics of the Irminger Current in the summer of 1955 with those in 1957 - 1958, it is seen that the Atlantic Water of the Irminger Current (northern branch), which is observed north of 65° N, circulates around the west coast of Iceland with Denmark Strait and enters (shelf waters) within the 200-m isobath. Members of the SCOTIA expedition think that regular water movements do not occur on the shelf, but that the Atlantic Water may penetrate it at times. According to our data, such a regular water flow occurs here (at least north of 65° N), but it is weaker than in the seaward part (see tables 5, 7) of the area.

In conclusion, let us examine the speeds of the East Greenland Current. V. Yu. Vize calculated the current speeds from data obtained from drifting vessels, buoys, and other objects. We used some of the values (table 9) that give the velocity of the East Greenland Current (5).

Table 9

Latitude	Current Speed (miles per day)	Latitude	Current Speed (miles per day)
71°	7.0	67°	9.7 (21 cm/s)
70°	9.2	66°	12.7 (27 cm/s)
69°	9.7	65°	16.6 (36 cm/s)
68°	9.7	64°	18.5 (40 cm/s)

The small cross-section across the East Greenland Current north of latitude 65° N (table 10) shows that the maximum current velocity was only 4.4 cm/s. The narrow shelf belt of Greenland, where "pure" Arctic Water occurs, as a rule was covered by drift ice. Our hydrologic observations covered the area by the ice edge, which was some distance from the core of the current, where the velocity is greater. The same speeds (4 to 6 cm/s) were observed by German investigators in the summer of 1955 (ANTON DOHRN). A little north of 65° N the velocity in the core of the current reaches 10 to 15 cm/s, according to the German observers. We can assume (based on earlier comparisons between our and German data) that velocities in the core of the East Greenland Current are the same.

Table 10

Current speeds in cm/s in Denmark Strait in the summer of 1958 in a cross-section along the southeast coast of Greenland.

Depth (m)	1634–1635	1635–1636	1636–1637
0	–4,4	–0,9	–7,4
10	–4,2	–2,0	–2,6
20	–3,7	–2,0	+0,4
30	–3,3	–2,3	+2,2
50	–2,4	–2,9	+4,1
100	–1,3	–2,0	+5,9
200	–0,9	—	—
300	—	0	—

According to the SEVASTOPOL' studies in the summer of 1957 (table 11), north of 66° N (in 1958 north of 65° N) the current velocities of East Greenland Current area are different. As is known, the speed of the East Greenland Current decreases to the north (table 9). Nevertheless, the speeds calculated from the summer 1957 observations are 2 to 3 times greater (10.2 to 13.7 cm/s) than the corresponding figues in 1958. However, in this case also our data are considerably less than those obtained by V. Yu. Vize (see table 9).

Table 11

Current speeds in Denmark Strait in the summer of 1957 at stations 1167 to 1171.

Depth (m)	1167—1168	1168—1169	1169—1170	1170—1171
0	—10,25	—13,68	+1,00	—10,53
10	—9,75	—13,20	+2,20	—10,26
20	—9,50	—12,48	+1,80	—7,83
30	—9,00	—11,76	+1,40	—6,21
50	—7,00	—10,80	+1,00	—4,60
100	—5,00	—6,00	+1,00	—3,51
200	—5,25	+1.92	+0,20	+1,89
300	—1,75	—	—	—

Note: Location of St. 1167 - 66° 08' N, 30° 56' W;
Location of St. 1171 - 66° 24' N, 33° 34' W.

We do not know when and in what conditions the data by V. Yu. Vize were obtained, but lacking other data they serve us as a definite orientation point. Thus, in the summers of 1955 and 1958 the Irminger and Greenland Currents were rather weak, but in 1957 they were stronger.

V. A. Berezkin pointed out that there is a connection between the Atlantic and East Greenland Currents. It should be assumed that by analogy with the intensification or attenuation of the Irminger Current (North Atlantic), the East Greenland Current experiences corresponding fluctuations. Such a comparison seems reasonable for the summers of 1955, 1957, and 1958.

Conclusions

1. Detailed consideration of the geographic distribution of the physico-chemical characteristics and the analysis of T-S curves show that within Denmark Strait two basic water masses predominate: water of Atlantic origin and polar Arctic waters. The first are characterized by high salinity (above $35^{o}/oo$) and by relatively high temperature (5^{o} to 8^{o} C); the second by comparatively low salinity (31^{o} to $34^{o}/oo$) and low temperature (below 0^{o} C). During the period of our investigations, certain deviations from these data, which were determined by various cases of local and seasonal nature, were observed.

As a result of the convergence of warm Atlantic and cold Polar waters, the zone of their interaction a new water mass is formed with intermediate characteristics.

Moreover, another water mass is observed, Mixed Water, i.e. Atlantic Water and fresh water continental (insular) run-off. These waters form the surface layer to 30 to 50-m depths in a narrow coastal zone of the Icelandic area and are characterized by a high temperature of 9^{o} to 11^{o} C and by a salinity of 34.6 to $34.9^{o}/oo$.

2. The convergence of the Atlantic and polar waters determines the presence of a clearly defined front that is represented by a narrow, winding undulatory zone having the largest temperature and salinity gradients at the surface. In the Anton Dohrn Bank area the temperature gradients at the surface are 1 to 2^{o} per mile and the salinity gradients 0.1 to $0.2^{o}/oo$ per mile. The line of the Polar Front intersects Denmark Strait and stretches along the southeast coast of Greenland. The wave-like form of this line, in many respects, is conditioned by the complicated, broken-up relief of the Greenland-Iceland Ridge, which determines the stream displacements of the various waters and causes vortical water movements to form.

3. In the entire area of contact of Atlantic with Polar waters, a phenomenon of "diving" (plunging) of the denser Atlantic Waters, in the form of an intermediate layer, can be traced along almost the entire southeast Greenland coast. The presence of this layer and the fluctuation of its strength determine the thickness of the superficial layer of Polar Water and the high bottom temperature (3 to 5^{o} C) along the southeast Greenland coast (beyond the outer edge of floating ice).

4. The comparatively low temperatures at the bottom in the central part of the Greenland-Iceland Ridge are explained, either by the residual traces here of the vertical cold connection, or by the pulsating inflows of Greenland Sea waters.

5. Comparison of the distribution of the physico-chemical characteristics

with time leads to conclusion concerning various dynamic activities of Denmark Strait waters in the summer season over a period of years and even during one summer.

6. The stability of the water masses of Denmark Strait is very variable. Atlantic Waters in the surface layer (0 to 10 m deep) and with a range in some cases of 10 to 20 m are unstable, due to wind mixing. Deviations within this pattern develop under the influence of seasonal and local factors: near the coasts is the effect of the island run-off; farther offshore is the influence of the proximity of the Polar Front, i.e. the possibility of an influx of less dense waters of different origin and sometimes of floating ice.

The basic water mass in a layer 20 to 200 m deep has a positive stability that is greatest at depths of 20 to 30 m and 30 to 50 m, i.e. in the zone of great temperature gradients. Below Greenland current, the waters are characterized by much greater stability than the area of the prevailing Atlantic Water (primarily in their superficial layers). The differences of stability are conditioned by the various formation processes of these waters.

7. In summer, 1958, the Irminger and East Greenland currents were characterized by very low velocities. In the area of the extension of the Irminger current, swirls and eddies, which apparently are temporary and depend on fluctuations in the strength of this current over the years and in the separate phases of the yearly cycle, have been found. The basic stream of Atlantic Waters, which is observed between 27° and 29° W, is diverted westward by the Greenland-Iceland Ridge and under the pressure of Polar Waters circulates along the deeps of the continental slope of the Greenland coast in southerly and southwesterly directions.

Atlantic Waters penetrate the area north of Iceland on their way down the west coast north of 65° N and enter the shelf zone. It is possible that under particularly unfavorable hydrometeorologic conditions (strong and prolonged winds in the northern half of the horizon), the weak flow in the narrow coastal zone of Iceland may cease, because it cannot cross over the Greenland-Iceland Ridge and join the basic mass of Atlantic Water which has its interrupted southward circulation in Denmark Strait. Comparison of the current velocities in the summers of 1955, 1957 and 1958 shows considerable fluctuations in the strength of the basic water flow in Denmark Strait. The Irminger Current apparently merges with the East Greenland Current.

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